PARTICLE

Prize in physics. But this knowledge had yet to percolate out of academic research labs such as the Cavendish and into industrial workshops. Although he had earned a Ph.D. in physics from Yale, in his daily practice de Forest remained pretty much a systematic tinkerer in the Edisonian vein, trying endless variations on his gadgets in his halting attempts to improve their performance.

VOLUMES COULD be written about the practical applications that owe their existence to the understanding of electricity as a stream of subatomic particles rather than a continuous fluid. While the telephone clearly antedated the discovery of the electron, for example, its modern manifestations—cellular and touchtone phones, telefax machines, satellite communications—would be utterly impossible without such knowledge. And the ubiquitous television set is of course just a highly refined version of the cathode-ray tube that Thomson used to determine the charge-to-mass ratio of his beloved corpuscle. The field of electronics, a major subfield of electrical engineering today, grew up in the twentieth century around this new conception of electricity, eventually taking its name in the 1920s from the particle at its core. (We are perhaps fortunate that Thomson did not prevail in his choice of nomenclature!)

In parallel with the upsurge of electronics, and in some part due to it, came a sweeping transformation of industrial research in America. Once the main province of highly individualistic inventors searching for a fruitful breakthrough, technology development slowly became an organized practice performed by multidisciplinary teams of salaried scientists and engineers working in well-equipped industrial labs. As the century waxed and quantum mechanics emerged to explain the mysterious behavior of electrons, atoms and molecules, these researchers increasingly sported advanced degrees in physics or chemistry. A deeper understanding of the scientific principles governing the behavior of matter gradually became indispensable to the practice of industrial research. As the noted historian of technology Thomas Hughes put it, "Independent inventors had manipulated machines and dynamos; industrial scientists would manipulate electrons and molecules."

Few examples illustrate this evolutionary transformation better than the case of the vacuum-tube amplifier. For almost a decade after de Forest invented it, his audion found little use beyond low-voltage applications in wireless receivers—as a detector of weak radio signals. He simply did not understand that the gas remaining in his tube was impeding the flow of electrons from filament to plate. At the higher voltages required for serious amplification, say in telephone communications, the device began, as one observer noted, "to fill with blue haze, seem to choke, and then transmit no further speech until the incoming current had been greatly reduced."

One corporation extremely interested in amplifying telephone signals was the American Telephone and Telegraph Company, then seeking to develop a suitable "repeater" for transcontinental phone service.